

## CLAIMS

### What is Claimed is:

1. A high-current, high-gradient, high-efficiency, multi-stage cavity cyclotron resonance accelerator (MCCRA) for accelerating charged particles, comprising:

5 a charged particle source for emitting pulses of said charged particles;

a plurality of successive rotating mode cavities extending in an axial direction and coupled to said charged particle source, wherein each successive cavity resonates at a progressively-lower RF resonance frequency to maintain approximate resonance of said pulses of charged particles, with the respective RF resonance frequency of each said successive cavity decreasing in substantially equal increments corresponding to a difference frequency, and said pulses of said charged particles being emitted in correspondence with said difference frequency; and

15 at least one solenoid coil coaxially disposed about said cavities, said solenoid coil proving a substantially uniform magnetic field along an axial extent of said plurality of successive cavities.

2. The MCCRA of Claim 1, further comprising a coaxial dielectric liner disposed in at least one of said plurality of cavities.

3. The MCCRA of Claim 1, further comprising a plurality of radial vanes disposed in at least one of said plurality of cavities.

4. The MCCRA of Claim 3, wherein said plurality of radial vanes further comprise four radial vanes adapted to provide a radio-frequency double-dipole (RFDD).

5. The MCCRA of Claim 1, wherein said charged particles are selected from a group consisting of ions, electrons, protons, and muons.

6. The MCCRA of Claim 1, wherein each of said plurality of cavities resonates in a  $TE_{111}$  mode.

7. A method of accelerating charged particles, comprising the steps of:  
emitting said charged particles in pulses from a charged particle source;  
5 transmitting said charged particle in an axial direction through a plurality of successive rotating mode cavities extending in an axial direction;  
providing a substantially uniform magnetic field along an axial extent of said plurality of successive cavities; and  
operating each successive cavity at a progressively-lower RF resonance  
10 frequency to maintain approximate resonance of said pulses of charged particles with the respective RF frequency of each said successive cavity decreasing in substantially equal increments corresponding to a difference frequency, and said pulses of said charged particles being emitted in correspondence with said difference frequency.

8. The method of Claim 7, wherein the emitting step further comprises emitting said pulses of said charged particles at time intervals corresponding to an inverse of said difference frequency.

9. The method of Claim 7, further comprising the step of capacitively loading at least one of said plurality of cavities.

10. The method of Claim 7, wherein said charged particles are selected from a group consisting of ions, electrons, protons, and muons.

11. The method of Claim 7, wherein said operating step further comprises resonating each of said plurality in a  $TE_{111}$  mode

12. A system for accelerating charged particles, comprising:  
means for emitting pulses of said charged particles;  
means for transmitting said charged particle in an axial direction through a  
plurality of successive rotating mode cavities extending in an axial direction;  
5 means for providing a substantially uniform magnetic field along an axial  
extent of said plurality of successive cavities; and  
means for operating each successive cavity at a progressively-lower RF  
frequency to maintain approximate resonance of said charged particle with the  
respective RF frequency of each said successive cavity decreasing in  
10 substantially equal increments corresponding to a difference frequency, and said  
pulses of said charged particles being emitted in correspondence with said  
difference frequency.

13. The system of Claim 12, wherein each of said plurality of cavities  
resonates in a  $TE_{111}$  mode.

14. The system of Claim 12, further comprising means for reducing cutoff  
frequency for desired dipole modes.

15. The system of Claim 12, wherein said charged particles are selected from  
a group consisting of ions, electrons, protons, and muons.

16. The system of Claim 12, further comprising means for controlling an  
20 amount of power supplied to each one of said plurality of successive cavities.